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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/726,638	12/04/2003	Ja-Hum Ku	2421-000030/US	6177

30593 7590 03/06/2010

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ART UNIT	PAPER NUMBER
2812	

MAIL DATE	DELIVERY MODE
03/06/2010	PAPER

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte JA-HUM KU, KWAN-JONG ROH, MIN-CHUL SUN, and MIN-JOO KIM

Appeal 2009-014245
Application 10/726,638[1]
Technology Center 2800

Decided: March 8, 2010

Before MAHSHID D. SAADAT, SCOTT R. BOALICK, and THOMAS S. HAHN, *Administrative Patent Judges.*

BOALICK, *Administrative Patent Judge.*

DECISION ON APPEAL

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[1] Application filed December 4, 2003. Application 10/726,638 claims the benefit under 35 U.S.C. § 119 of Korean Patent Application No. 2003-42838, filed June 27, 2003. The real party in interest is Samsung Electronics Co., Ltd.

This is an appeal under 35 U.S.C. § 134(a) from the final rejection of claims 1-34. Claims 35-37 have been cancelled. We have jurisdiction under 35 U.S.C. § 6(b).

We reverse.

STATEMENT OF THE CASE

Appellants' invention relates to methods for forming a nickel silicide layer on semiconductor devices. (Spec. Abstract.) The nickel silicide layer is formed from a nickel alloy that includes an alloying metal, such as tantalum. (Spec. Abstract.) The nickel silicide layer includes a lower layer formed primarily of nickel and silicon and an upper layer incorporating the majority of the alloying metal. (Spec. Abstract.)

Claim 1 is exemplary:

1. A method of forming a nickel silicide layer on an exposed silicon surface comprising:

depositing a nickel alloy layer on the exposed silicon surface, the nickel alloy including nickel and an alloying metal that constitutes no more than about 10 atomic percent of the nickel alloy;

reacting the nickel alloy layer with the exposed silicon surface to form a nickel silicide layer having an upper layer and a lower layer, wherein the alloying metal is preferentially segregated in the upper layer.

The prior art relied upon by the Examiner in rejecting the claims on appeal is:

Chittipeddi	6,498,080 B1	Dec. 24, 2002
Amos	6,846,734 B2	Jan. 25, 2005 (filed Nov. 20, 2002)

Cabral	2005/0176247 A1	Aug. 11, 2005 (filed Mar. 8, 2005, divisional of U.S. Patent No. 6,905,560, filed Dec. 31, 2002)

Claims 1-4, 7-9, 15-18, 26, 28, 29, and 31-34 stand rejected under 35 U.S.C. § 102(e) as being anticipated by Cabral.

Claim 30 stands rejected under 35 U.S.C. § 103(a) as being obvious over Cabral.

Claims 5, 6, 10-14, 19, 20, and 27 stand rejected under 35 U.S.C. § 103(a) as being obvious over Cabral and Amos.

Claims 21-25 stand rejected under 35 U.S.C. § 103(a) as being obvious over Cabral and Chittipeddi.

ISSUE

With respect to independent claims 1 and 15, Appellants argue that Cabral does not teach the limitation "reacting the nickel alloy layer with the exposed silicon surface to form a nickel silicide layer having an upper layer and a lower layer, wherein the alloying metal is preferentially segregated in the upper layer." (App. Br. 10-12; *see also* Reply Br. 4-6.) In particular, Appellants argue that "the Examiner does not provide the required objective evidence or cogent technical reasoning to support his conclusion of inherency" (App. Br. 11; Reply Br. 4) and "Cabral actually discloses that the nickel alloy layer is a single layer, rather than a nickel silicide layer having an upper and lower layer as recited in independent claim 1" (App. Br. 12).

Appellants' arguments present the following issue:

Does Cabral teach "reacting the nickel alloy layer with the exposed silicon surface to form a nickel silicide layer having an upper layer and a lower layer, wherein the alloying metal is preferentially segregated in the upper layer"?

FINDINGS OF FACT

The record supports the following findings of fact (FF) by a preponderance of the evidence.

Specification

1. Appellants describe "forming a nickel silicide layer by the reaction between a nickel alloy and an exposed silicon surface." (¶ [0007].) For example, the nickel silicide layer can be used as conductors for the gate, source and drain regions for metal oxide semiconductor (MOS) devices. (¶ [0003].) Tantalum is added to the nickel alloy at levels of "up to at least about 10 atomic percent, with levels in the range of between about 0.1 atomic percent and about 5 atomic percent, and particularly about 3.5 atomic percent exhibiting acceptable performance." (¶ [0011].)

2. The nickel silicide is formed by "heating the nickel alloy in contact with a silicon surface to a temperature above about 200 °C. and below about 700 °C., more typically between about 250 °C. and about 500 °C., for a period of at least about 10 seconds and possibly 30 minutes or longer." (¶ [0016].) "The particular time and temperature

combination selected should be sufficient to produce the two-layered nickel silicide structure." (¶ [0016].)

3. In one embodiment, as illustrated in Figure 2C, a nickel alloy layer 30 is deposited over an active region of a silicon substrate and annealed "for a time period sufficient" to form a silicide. (¶ [0035].) This reaction is performed using a rapid thermal anneal (RTP) process at a temperature "typically above 450 °C." (¶ [0035].)

4. In another embodiment, a series of 130 Å-thick (i.e., 13 nm-thick) nickel silicides were formed. (¶ [0052].) These nickel silicides were processed by sputtering nickel alloys containing tantalum (3.5, 5.0 and 10.0 atomic %) on silicon substrates, followed by annealing at 450 °C for thirty seconds. (¶ [0052].) Upon completion of the annealing step, a tantalum-rich upper layer and a NiSi lower layer were formed. (¶ [0053]; Table 2.)

Cabral

5. Cabral relates to "a method of fabricating a low resistance non-agglomerated Ni monosilicide contact" for semiconductor devices (¶ [0001]), such as contacts for CMOS devices (¶ [0009]). Tantalum is added as an alloying element to a Ni monosilicide phase to retard agglomeration. (¶ [0036].)

6. To form CMOS contacts (¶ [0009]), a Ni alloy layer is formed over a portion of a Si-containing material (¶ [0011]). Preferably, the Ta

alloying element (¶ [0036]) is present in the Ni alloy layer in an amount from 0.5 atomic % to 10 atomic % (¶ [0039]). The Ni alloy layer can be deposited by sputtering to a thickness of 30 nm or less. (¶ [0038].) The "Ni alloy layer [is annealed] at a temperature which is effective in converting a portion of said Ni alloy layer into either a Ni alloy monosilicide layer or a metal rich Ni silicide layer." (¶ [0012].) The metal-rich silicide phases can include Ni_3Si_2, Ni_2Si, $Ni_{31}Si_{12}$ and Ni_3Si. (¶ [0047].)

7. The annealing step is performed by rapid thermal anneal (RTA) at about 650 °C for thirty minutes. (¶ [0045].) Other annealing temperatures include from about 250 to 600 °C, preferably 400 °C to 550 °C. (¶ [0045].) Low temperature annealing (i.e., below 500 °C or preferably below 350 °C) results in the formation of metal-rich silicide phases. (¶ [0047].) If this metal-rich silicide is formed during annealing, a second anneal is required to form a low resistivity Ni monosilicide. (¶ [0020].) Cabral is silent regarding the microstructure of the Ni monosilicide layer and the metal-rich Ni silicide layer during annealing.

PRINCIPLES OF LAW

Anticipation is established when a single prior art reference discloses, expressly or under the principles of inherency, each and every limitation of the claimed invention. *Atlas Powder Co. v. IRECO, Inc.*, 190 F.3d 1342, 1347 (Fed. Cir. 1999); *In re Paulsen*, 30 F.3d 1475, 1478-79 (Fed. Cir. 1994). Inherency may not be established by probabilities or

possibilities, and "[t]he mere fact that a certain thing may result from a given set of circumstances is not sufficient." *Continental Can Co. v. Monsanto Co.*, 948 F.2d 1264, 1268 (Fed. Cir. 1991).

ANALYSIS

We conclude that the Examiner erred in rejecting claims 1-4, 7-9, 15-18, 26, 28, 29 and 31-34 under 35 U.S.C. § 102(e) and claims 5, 6, 10-14, 19-25, 27 and 30 under 35 U.S.C. § 103(a).

Claims 1-4, 7-9, 15-18, 26, 28, 29 and 31-34

Appellants' argument (App. Br. 10-12; *see also* Reply Br. 4-6) that Cabral does not teach the limitation "reacting the nickel alloy layer with the exposed silicon surface to form a nickel silicide layer having an upper layer and a lower layer, wherein the alloying metal is preferentially segregated in the upper layer," as recited in independent claim 1, is persuasive.

The Examiner found that Cabral teaches all the features of independent claim 1. (Ans. 3-4, 7.) In particular, the Examiner found that Cabral inherently teaches the limitation "reacting the nickel alloy layer with the exposed silicon surface to form a nickel silicide layer having an upper layer and a lower layer, wherein the alloying metal is preferentially segregated in the upper layer." (Ans. 3-4.) In reaching this conclusion, the Examiner reasoned that

> Cabral . . . discloses embodiments including the claimed alloying elements in the claimed compositions and therefore it would be expected that a similar result would be achieved with the reacting process step, particularly since the temperature range of the reacting step of 250-600 Celsius . . . is substantially the same or at the very least is contained within the temperature

> range of 200-700 Celsius in the reacting step of the instant application.

(Ans. 7.) We do not agree.

Appellants' Specification discloses forming a nickel silicide layer for semiconductor device conductors by annealing a nickel alloy layer containing up to 10 atomic % tantalum formed over a silicon substrate. (FF 1-4.) Appellants' Specification further discloses that a two-layered nickel silicide structure can be formed by annealing the nickel alloy layer at a temperature between 200 °C and 700 °C for ten seconds to thirty minutes (FF 2) by rapid thermal annealing (FF 3-4). Cabral relates to Ni monosilicide contacts for CMOS devices. (FF 5.) Cabral teaches that a Ni alloy layer containing 0.5 atomic % to 10 atomic % tantalum is deposited over a Si-containing material and annealed (FF 6) at a temperature of 250 to 600 °C for thirty minutes (FF 7).

Although the nickel alloy layer composition and the processing conditions (i.e., range of annealing temperatures and times) disclosed in Appellants' Specification (*see* FF 1-4) are similar to those taught by Cabral (*see* FF 5-7), they do not necessarily produce similar results. Appellants' Specification discloses that a two-layered nickel silicide structure can be formed by annealing the nickel alloy layer at a temperature below 500 °C for thirty minutes. (*See* FF 2.) However, Cabral teaches that annealing the Ni alloy layer at below 500 °C for thirty minutes results in the formation of a metal-rich silicide phase (FF 7), rather than a two-layered nickel silicide structure. Cabral teaches that a second anneal is required to transform this metal-rich silicide phase to a Ni monosilicide layer. (FF 7.) However, Cabral is silent regarding the microstructure of the Ni monosilicide layer and

the metal-rich Ni silicide silicide layer during annealing. (FF 7.) Thus, the Examiner has not established that the limitation of "reacting the nickel alloy layer with the exposed silicon surface to form a nickel silicide layer having an upper layer and a lower layer, wherein the alloying metal is preferentially segregated in the upper layer" is necessarily present in Cabral. Accordingly, the Examiner has erred in finding via inherency that Cabral teaches the limitation "reacting the nickel alloy layer with the exposed silicon surface to form a nickel silicide layer having an upper layer and a lower layer, wherein the alloying metal is preferentially segregated in the upper layer," as recited in claim 1.

Thus, we conclude that the Examiner has erred in rejecting claim 1 under 35 U.S.C. § 102(e). Claims 2-4 and 7-9 depend from independent claim 1, and we conclude that the Examiner has erred in rejecting these claims for the reasons discussed with respect to independent claim 1. Independent claim 15 recites limitations similar to those discussed with respect to independent claim 1, and we further conclude that the Examiner has erred in rejecting this claim, as well as claims 16-18, 26, 28, 29 and 31-34 which depend from claim 15, for the reasons discussed with respect to claim 1.

Claim 30

Claim 30 depends from independent claim 15 and the Examiner has erred in rejecting claim 15 for the reasons previously discussed.

Claims 5, 6, 10-14, 19, 20 and 27

Claims 5, 6, 10-14, 19, 20 and 27 depend from independent claims 1 and 15, and the Examiner has erred in rejecting claims 1 and 15 for the reasons previously discussed. Amos does not cure the above-noted deficiencies of Cabral.

Claims 21-25

Claims 21-25 depend from independent claim 15 and the Examiner has erred in rejecting claim 15 for the reasons previously discussed. Chittipeddi does not cure the above-noted deficiencies of Cabral.

CONCLUSION

Based on the findings of fact and analysis above, we conclude that the Examiner has erred in rejecting claims 1-34.

DECISION

The rejection of claims 1-34 is reversed.

REVERSED

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